

PATENT ABSTRACTS OF JAPAN

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(54) MAGNETO-OPTICAL RECORDING MEDIUM, AND METHOD OF  
MANUFACTURING THE SAME

(57)Abstract:

PROBLEM TO BE SOLVED: To provide the magneto-optical recording medium of a DWDD reproducing system in which a magnetic domain wall is stably moved and cross light is prevented while adopting land/groove recording in order to make a track pitch narrow.

SOLUTION: A magneto-optical recording medium 10 is a magnetic domain wall movable magneto-optical recording medium provided with a magnetic layer 16 where a magnetic domain wall movable reproducing layer, a switching layer, and a recording holding layer are multiply layered, and both a land 11 and a groove 12 are used as recording/reproducing tracks but magnetism is changed by irradiating a side wall portion 13 located between the land 11 and the groove 12 with a light beam 21 in advance to magnetically part a space between the land 11 and the groove 12. Further, a step between the land 11 and the groove 12 is made shallower than the conventional magneto-optical recording medium for land/groove recording by making the step into

1/32 to 1/8 of the wavelength of a light source to be used for recording/reproducing and by making the inclination angle of the side wall portion into 20° to 60° .

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CLAIMS

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[Claim(s)]

[Claim 1] By modulating an impression field, having a domain-wall-displacement mold playback layer, a switching layer, and a record maintenance layer, and irradiating the light beam for record By recording information on record / playback field, and irradiating the light beam for playback to said record / playback field By moving the magnetic domain wall of a record mark in said domain-wall-displacement mold playback layer, widening this record mark, and detecting change of the plane of

polarization which the reflected light of said light beam for playback has The magneto-optic-recording medium characterized by having the land and groove on which both information is recorded in the magneto-optic-recording medium by which said information is reproduced, and for the side-attachment-wall section located between this land and this groove deteriorating by annealing, and cutting magnetic association between said lands and said grooves.

[Claim 2] The magnetization direction of said side-attachment-wall section is a magneto-optic-recording medium according to claim 1 which has become in the field.

[Claim 3] The level difference of said land and said groove is a magneto-optic-recording medium according to claim 1 which is 1/32 to 1/8 of light source wavelength used for record and playback.

[Claim 4] The tilt angle of said side-attachment-wall section is a magneto-optic-recording medium according to claim 1 which is 20 degrees to 60 degrees.

[Claim 5] By modulating an impression field, having a domain-wall-displacement mold playback layer, a switching layer, and a record maintenance layer, and irradiating the light beam for record By recording information on record / playback field, and irradiating the light beam for playback to said record / playback field By moving the magnetic domain wall of a record mark in said domain-wall-displacement mold playback layer, widening this record mark, and detecting change of the plane of polarization which the reflected light of said light beam for playback has In the manufacture approach of a magneto-optic-recording medium that said information is reproduced Said domain-wall-displacement mold playback layer, The manufacture approach of the magneto-optic-recording medium characterized by irradiating the light beam for annealing and cutting magnetic association between said lands and said grooves in the side-attachment-wall section located between the lands and grooves which record both information after forming said switching layer and said record maintenance layer.

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#### DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to a super-high density magneto-optic-recording medium.

[0002]

[Description of the Prior Art] Information is recorded by writing a magnetic domain in a magnetic thin film, using the heat energy of semiconductor laser as a rewritable high density record medium, and there is a magneto-optic-recording medium which can read information using the optical magneto-optical effect. In recent years, the demand of the further raise in the recording density of a magneto-optic-recording medium is increasing.

[0003] It depends for the track recording density of a magneto-optic-recording medium on the laser wavelength of playback optical system, and the numerical aperture of an objective lens greatly. However, since there is a limitation in an improvement of the laser wavelength of playback optical system, and the numerical aperture of an objective lens, the technique of improving recording density with devising the configuration and the approach of reading of a record medium is developed.

[0004] For example, there is a DWDD (DomainWall Displacement Detection) technique currently indicated by JP,06-290496,A. According to this, in the configuration of the multilayers which have the domain-wall-displacement mold playback layer and switching layer which were combined magnetically, and a record maintenance layer, information is recorded on a record maintenance layer. And without changing the information recorded on the record maintenance layer using the temperature gradient by the exposure of a light beam, at the time of information playback, the magnetic domain wall of the record mark of the magnetic domain wall moving bed is moved, and a record mark is widened to it. And change of the plane of polarization of the light beam reflected light is detected. According to this approach, playback of the record mark below the diffraction limitation of light is possible, and the magneto-optic-recording medium recording density and whose transfer rate improved sharply becomes realizable.

[0005] In addition, by this magneto-optic-recording medium, in order that migration of the magnetic domain wall of the record mark in a domain-wall-displacement mold playback layer may make it easy to happen using the temperature gradient by the exposure of a light beam, elevated-temperature annealing treatment of the groove is carried out to both the contiguity groove that faces across record and a regenerative track by irradiating a high-power laser beam, and annealing treatment which deteriorates the record-medium layer of a groove part is performed. The effectiveness of not becoming the magnetic domain which the magnetic domain wall which forms a record mark closed by this annealing treatment can be acquired. Since

it becomes movable [ the magnetic domain wall which the operation of magnetic domain wall coercive force was mitigated, and was stabilized more by this ], a better regenerative signal can be acquired. However, in order to carry out elevated-temperature annealing treatment of the groove, it is difficult to attain narrow track pitch-ization.

[0006] So, annealing treatment is not performed aiming at the further densification, but, recently, the research on a magneto-optic-recording medium usable as record and a regenerative track is prosperous also in a groove part. According to this, densification becomes possible in the direction of a path of a magneto-optic-recording medium. For example, in JP,11-195252,A, the land groove record medium of a deep groove is realized by controlling the surface roughness of the slot side-attachment-wall section in a substrate. Thus, the formation of a narrow track pitch of about 0.5 micrometers is possible for a magneto-optic-recording medium. According to the experiment, 0.11micrometers [/bit ] record playback is checked on practical use level as track recording density using the land groove substrate of a track pitch 0.6micrometer deep groove (a channel depth is about 100nm). This is equivalent to 2 10 Gbit(s)/inch as recording density.

[0007]

[Problem(s) to be Solved by the Invention] however, the domain wall displacement which was stabilized in land groove record sake -- about 100nm or more -- a trench is comparatively required. Therefore, the temperature distributions formed in the time of tracing the time of tracing the land and the groove section by approaching space-behavior of incident light differ greatly, and relative more bigger record reinforcement than the time of trace of the groove section is needed especially at the time of trace of a land. Therefore, when the land was recorded the optimal, there was a problem of carrying out the cross light of the groove section.

[0008] Land groove record being used for the purpose of this invention for the formation of a narrow track pitch, the stable domain wall displacement is possible for it, and it is to offer the magneto-optic-recording medium of the DWDD playback system which can prevent a cross light.

[0009]

[Means for Solving the Problem] At least, in order to attain the above-mentioned purpose, although the both sides of a land groove use this invention as record and a regenerative track in the domain-wall-displacement mold magneto-optic-recording medium by which the laminating of a domain-wall-displacement mold playback layer, a switching layer, and the record maintenance layer was carried out, it irradiates a light beam at the side-attachment-wall section beforehand located between a land and a groove, deteriorates magnetism, and divides between land grooves magnetically. Furthermore, the level difference of a land and a groove is set to 1/32 to 1/8 of light source wavelength used for record and playback, and is made smaller than the

conventional magneto-optic-recording medium for land groove record.

[0010]

[Embodiment of the Invention] Next, the gestalt of operation of this invention is explained with reference to a drawing.

[0011] When drawing 1 is referred to, the magneto-optic-recording medium 10 of 1 operation gestalt of this invention On the substrate 14 which has a land 11 and a groove 12, the substrate layer 15 and a magnetic layer 16, The laminating of the Uechi layer 17 and the protective layer 18 is carried out one by one, annealing treatment of the side-attachment-wall section 13 located between a land 11 and a groove 12 is carried out by the light beam (main beam) 21, magnetism deteriorates, and the configuration by which the land 11 and the groove 12 were divided magnetically is taken. A magnetic layer 16 consists of the domain-wall-displacement mold playback layer by which the laminating was carried out, a switching layer, and a record maintenance layer. The magneto-optic-recording media 10 are the wavelength of 660nm, and an object for record / playback of NA=0.60 of an objective lens. Moreover, the magneto-optic-recording medium 10 is a magneto-optic-recording medium for land groove record, and a track pitch (the ratio of the width of face of a land truck and a groove truck is about 1:1) is [ the tilt angle of about 40nm and the side-attachment-wall section 13 of the depth of 0.5 micrometers and a groove 12 ] about 30 degrees. The wavelength of the light beam 21 for annealing is 410nm, and NA is 0.85. With this operation gestalt, the light beam incidence from the opposite side of a substrate which is easy to maintain the grace of a minute spot is adopted.

[0012] Reference of drawing 2 shows drawing which looked at the magneto-optic-recording medium 10 from the top with arrangement of a light beam. A main beam 21 is condensed to the side-attachment-wall section 13, and the subbeam 22 and the subbeam 23 are condensed to the land 11 and the groove 12, respectively. A main beam 21 is the minute spot of high intensity, carries out annealing treatment of the side-attachment-wall section 13, and deteriorates the magnetism. The subbeam 22 and the subbeam 23 are needed for the tracking of an actuator 41 so that it may mention later. The intensity ratio of a main beam 21 and the subbeams 22 and 23 is set up so that it may become 1:0.1 to about 0.2, and the effect of annealing treatment appears in a land 11 and a groove 12. In addition, the usual push pull signal is not acquired at the spot of NA0.85 of the wavelength of 410nm, and an objective lens. Then, in order to acquire a push pull signal, the beam diameter of the subbeams 22 and 23 is fattened.

[0013] Reference of drawing 3 shows the conceptual diagram of the annealing treatment and tracking equipment of the magneto-optic-recording medium 10. By dividing into three, the flux of light which does not receive diffraction for the flux of light from semiconductor laser 31 by the grating 32, and the two flux of lights which are the primary [ \*\*] diffracted light, a polarization beam splitter (PBS) 33 is made to

penetrate, and it considers as the parallel flux of light mostly with a collimator 34, and is made to condense as a main beam 21 and two subbeams 22 and 23 on the magneto-optic-recording medium 10 with an objective lens 36 through the quarter-wave length plate 35. In order to obtain the minute spot (main beam 21) of high intensity, wavelength of semiconductor laser 31 was set to 410nm as mentioned above, and NA=0.85 were used for the objective lens 36. In the rotational speed of 2–3m/s of the magneto-optic-recording medium 10, light source reinforcement was set up in search of the optimum value, while the reinforcement of a main beam 21 was about 5–7mW.

[0014] It is reflected by PBS33 and three beams reflected by the magneto-optic-recording medium 10 are condensed by the sensor 38 with the sensor lens 37. After it detects a tracking error (TE) from the output signal acquired from a sensor 38 and the annealing treatment of the side-attachment-wall section 13 finishes 1 round, in the contiguity side-attachment-wall section, the polarity of a tracking error is changed according to the inclination of a tracking error becoming opposite. In order to carry out annealing treatment of the next side-attachment-wall section based on the information from the tracking error generation circuit 43, a tracking servo is applied to an actuator 41 through the actuator drive circuit 42.

[0015] Reference of drawing 4 shows the conceptual diagram of the grating 32 which uses the subbeams 22 and 23 as the spot whose NA of an objective lens is 0.55 to about 0.60. The circle 321 of a dotted line shows the diameter of the flux of light on the grating 32 equivalent to the entrance pupil of an objective lens 36. The flux of light which a grating is formed in the field 322 smaller than it, consequently is diffracted turns into the flux of light thinner than an entrance pupil at the entrance pupil point of an objective lens 36, and is condensed on the magneto-optic-recording medium 10 as a beam extracted by low NA. In this case, since a non-diffracted-light bundle has the fall of a core on the strength, a main beam can also expect the so-called effectiveness of optical super resolution. In addition, when a push pull signal is acquired also at the wavelength of 410nm, and the spot of objective lens NA=0.85 with a groove configuration, a grating may be prepared in the field which exceeds the circle 321 of a dotted line as usually carried out.

[0016] Reference of drawing 5 shows the block diagram of a generation circuit in the tracking error which carries out the tracking of the main beam 21 on the side-attachment-wall section 13. A sensor 38 consists of division sensors 381, 382, and 383 of three groups, and spots 51, 52, and 53 are condensed on each division sensor corresponding to the light beams 21, 22, and 23 on the magneto-optic-recording medium 10. Based on  $(A+C)-(B+D)$ , a focal error signal is obtained from the division sensor 381. On the other hand, based on  $TE1=F-E$  and  $TE2=H-G$ , a push pull tracking error signal is acquired from the division sensors 382 and 383, respectively. Here, the well-known differential push pull method is applied to

the subbeams 52 and 23 [ 22 and ] 53, i.e., corresponding spots. Then, the repressed tracking error signal for DC offset can be acquired. In this way, the tracking servo stabilized at the time of the annealing treatment of the side-attachment-wall section 13 becomes possible. Thus, although the tracking servo is applied based on TE, as mentioned above, when moving to the next side attachment wall, the polarity of TE is changed and a tracking servo is applied.

[0017] Next, the examination result of the analysis of the optical spot profile based on vector analysis and the amount of light absorption of a thin film and the temperature-distribution analysis based on the thermal diffusion equation using the result further is explained about the annealing treatment of the side-attachment-wall section 13.

[0018] Drawing 6 shows the radial direction (direction of path) cross section of the light absorption distribution (exoergic distribution) at the time of irradiating the light beam for annealing centering on a side attachment wall. A side attachment wall shall be in the location of 0.25 micrometers of radial directions, and there shall be a land at the 0-micrometer core. It turns out that light absorption distribution has the peak near a land edge.

[0019] Drawing 7 shows the radial direction cross section of the temperature distribution at this time. Temperature distribution are the cases at the time of linear velocity 2.0 m/s. In this operation gestalt, 0.8 to about [ of peak temperature (degree C) ] 0.9 are set up with the threshold of annealing temperature. When the location (the dotted line shows the location of 0.85) used as relative intensity 0.8–0.9 is seen, it turns out reflecting light absorption distribution of drawing 6 that temperature distribution are unsymmetrical to a side-attachment-wall core. Therefore, when the light beam for annealing is irradiated centering on a side attachment wall, the width of face of a non-annealing field, i.e., the width of recording track of record playback, will differ by the land and the groove. Then, DETORAKKU of a minute amount is considered.

[0020] Reference of drawing 8 shows the location of a land groove, and the relation of TE mentioned above. When moving to contiguity side-attachment-wall section 13' from the side-attachment-wall section 13, the amount delta of offset for DETORAKKU remains as it is, and changes a polarity. By carrying out like this, DETORAKKU to a groove side or landau (drawing 8 groove side) can always be maintained.

[0021] Reference of drawing 9 shows light absorption distribution of the radial direction at the time of making the width of face of a side attachment wall DETORAKKU [ the optical spot for annealing ] about 1/4, and irradiating it from a side-attachment-wall core, to a groove side. If drawing 10 is referred to similarly, the temperature distribution of the radial direction at the time of making the spot for annealing DETORAKKU [ the width of face of a side attachment wall ] about 1/4, and

irradiating it from a side-attachment-wall core, to a groove side, are shown. It turns out too that light absorption distribution has the peak near a land edge. However, compared with the case, DETORAKKU, the light absorption near the groove edge by the side of an optical exposure location (generation of heat) is large. Consequently, it turns out that the symmetry is approached to a side-attachment-wall core so that temperature distribution may look at and understand the location (the dotted line shows the location of 0.85) used as relative intensity 0.8–0.9.

[0022] Next, the land groove structure in which good side-attachment-wall annealing treatment is possible is considered. Although drawing 10 of the symmetric property is better when the temperature distribution of drawing 7 are compared with the temperature distribution of drawing 10, the width of face of a temperature peak is wide. This shows that it is difficult for the direction in the case of drawing 10 [ DETORAKKU / drawing 10 ] to keep annealing treatment width of face narrow. And the difference between the temperature distribution of drawing 7 and the temperature distribution of drawing 10 originates in the light absorption distribution shown in drawing 6 and drawing 9, respectively. Then, conditions were changed, and the following thing was understood as a result of inquiring, analysis and. If the level difference of a land and a groove is enlarged, the amount made DETORAKKU in order for the difference between the peak of the light absorption near the land edge and the peak of the 2nd light absorption near the groove edge to become large, therefore to acquire good symmetry will become large. Consequently, the width of face of a temperature peak becomes large, and it becomes more difficult to keep annealing treatment width of face narrow. It is also the same as when a side-attachment-wall tilt angle is made steep. As for the level difference, the light absorption by the spot [ DETORAKKU / spot ], and the temperature distribution of the result showed that annealing treatment width of face will be settled in about 3 times of side-attachment-wall width of face to side-attachment-wall width of face, when the tilt angle of about 80nm and a side attachment wall was to about 60 degrees. In addition, 80nm is about about 1 of light source wavelength used for record and playback / 8. Moreover, the amount of DETORAKKU is about [ of side-attachment-wall width of face / 1/2 or less ] at the time of the above-mentioned conditions. Although carried out to to about 80nm of upper limits about the level difference, since it will be hard to acquire a push pull signal if shallow to remainder, a minimum is set to about 20nm. Moreover, if the tilt angle of a side attachment wall is loose to remainder, since the width of face of a land groove will become narrow, about 20 degrees is suitable for a minimum.

[0023] In this operation gestalt, about [ of the width of face of the side-attachment-wall section 13 ] 1/4 was made DETORAKKU [ a standard ], and annealing treatment was performed. Although the magnetic deterioration field which mainly serves as field inner magnet-ized film focusing on the side-attachment-wall

section 13 was made, it turned out that it is larger than side-attachment-wall width of face, and the width of face is smaller than the twice of side-attachment-wall width of face.

[0024]

[Effect of the Invention] Since according to this invention high density record of the direction of a path is possible, a light beam is irradiated at the side-attachment-wall section between land grooves, in order to use land groove record, magnetism is deteriorated and between land grooves is magnetically divided as explained above, stable domain-wall-displacement playback can be performed. Moreover, since it is possible to make the level difference of a land groove small, the effect of a cross light etc. can also be reduced.

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#### DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is drawing having shown the cross section of the magneto-optic-recording medium 10 of 1 operation gestalt of this invention.

[Drawing 2] It is drawing showing arrangement of a light beam collectively which looked at the magneto-optic-recording medium 10 from the top.

[Drawing 3] It is the conceptual diagram of the annealing treatment and tracking equipment of the magneto-optic-recording medium 10.

[Drawing 4] It is the conceptual diagram of a grating 32.

[Drawing 5] It is the block diagram of a tracking error generation circuit.

[Drawing 6] It is drawing showing the light absorption distribution at the time of irradiating the light beam for annealing centering on a side attachment wall.

[Drawing 7] It is drawing showing the temperature distribution at the time of irradiating the light beam for annealing centering on a side attachment wall.

[Drawing 8] It is drawing explaining the tracking error at the time of migration on a contiguity side attachment wall.

[Drawing 9] It is drawing showing the light absorption distribution at the time of making the width of face of a side attachment wall DETORAKU [ the light beam for annealing ] about 1/4, and irradiating it from a side-attachment-wall core to a groove

side.

[Drawing 10] It is drawing showing the temperature distribution at the time of making the width of face of a side attachment wall DETORAKKU [ the light beam for annealing ] about 1/4, and irradiating it from a side-attachment-wall core to a groove side.

[Description of Notations]

- 10 Magneto-optic-Recording Medium
- 11 Land
- 12 Groove
- 13 Side-Attachment-Wall Section
- 14 Substrate
- 15 Substrate Layer
- 16 Magnetic Layer
- 17 Uechi Layer
- 18 Protective Layer
- 21 Main Beam
- 22 SubBeam
- 23 SubBeam
- 31 Semiconductor Laser
- 32 Grating
- 33 Polarization Beam Splitter (PBS)
- 34 Collimator
- 35 Quarter-wave Length Plate
- 36 Objective Lens
- 37 Sensor Lens
- 38 Sensor
- 41 Actuator
- 42 Actuator Drive Circuit
- 43 Tracking Error Generation Circuit
- 21 Spot on Division Sensor 381 of Main Beam
- 22 Spot on Division Sensor 382 of SubBeam
- 23 Spot on Division Sensor 383 of SubBeam
- 321 Part equivalent to Entrance Pupil of Objective Lens 36
- 322 Grating Part
- 381-383 Division sensor